Environmental Controls

<Presenter>

Control issues

- Temperature Control
- Humidity Control
- Airflow Control
- Feedback and Diagnostics
- IT Integration
- Others

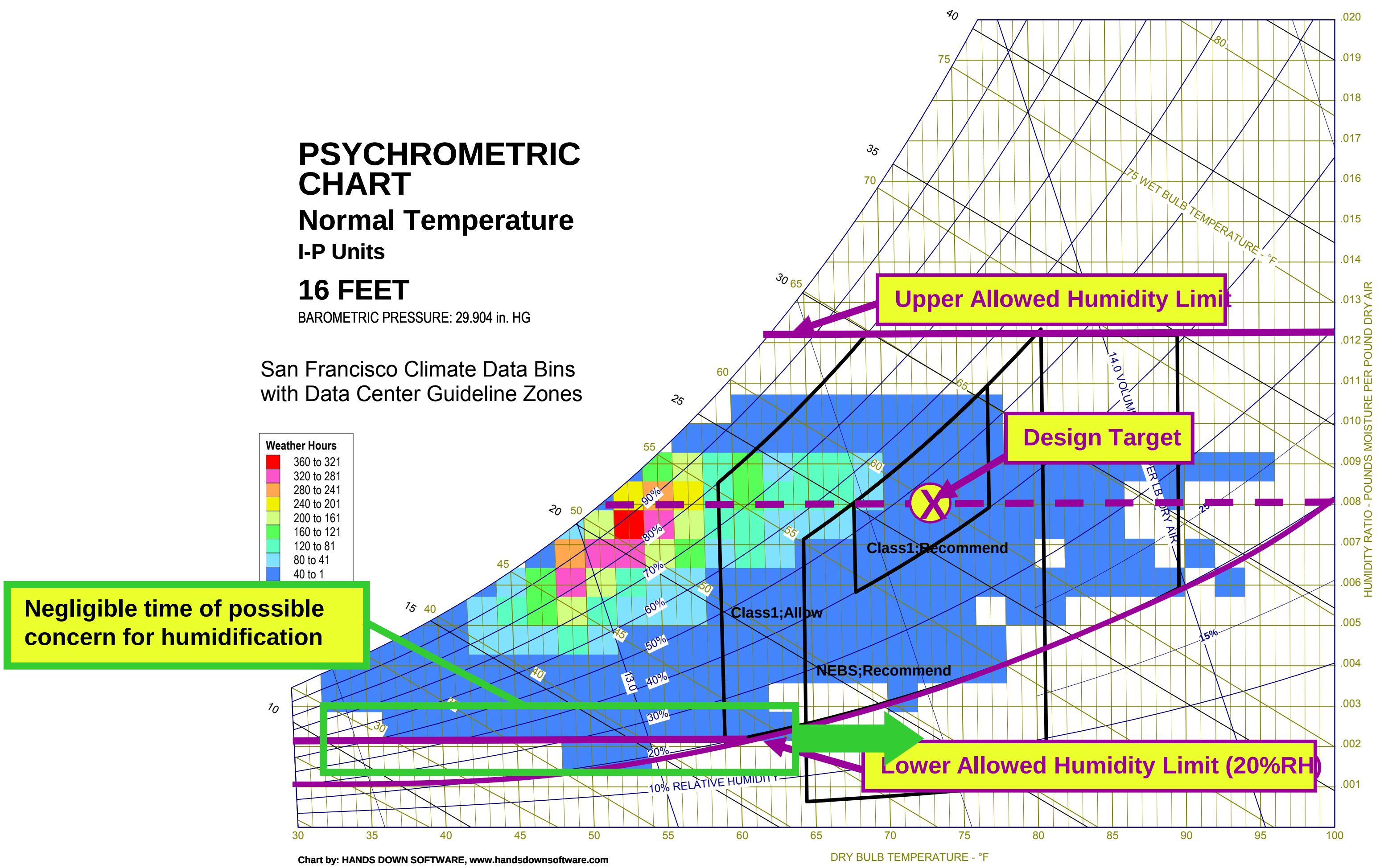
Design conditions at the equipment intakes

Table 2.1
Class 1, Class 2 and NEBS Design Conditions

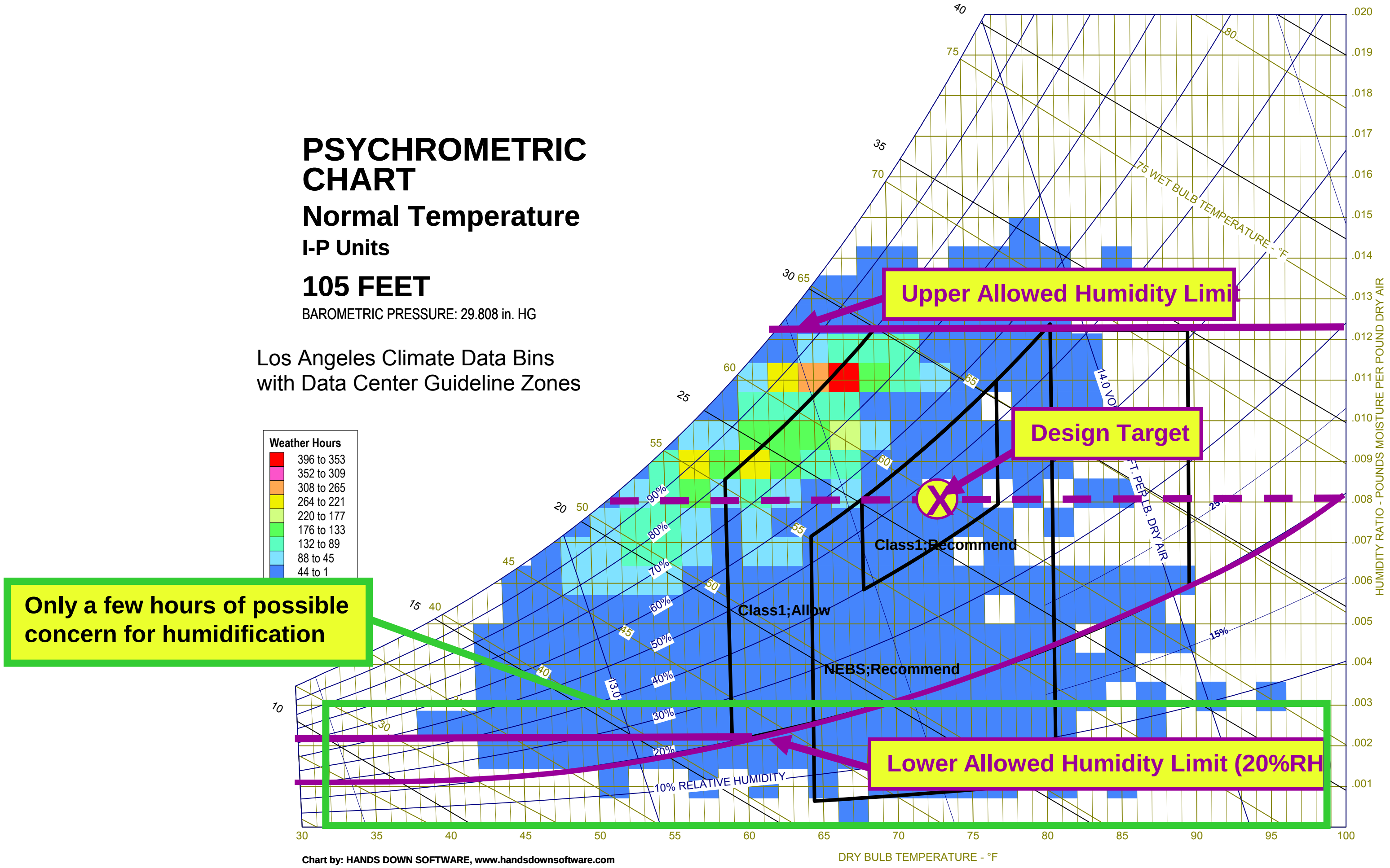
Condition	Class 1 / Class 2		NEBS	
	Allowable Level	Recommended Level	Allowable Level	Recommended Level
Temperature control range	59°F – 90°F[a,f] (Class 1) 50°F – 95°F[a,f] (Class 2)	68°F – 77°F[a]	41°F – 104°F[c,f]	65°F – 80°F[d]
Maximum temperature rate of change	9°F. per hour[a]		2.9°F/min.[d]	
Relative humidity control range	20% - 80% 63°F. Max Dewpoint[a] (Class 1) 70°F. Max Dewpoint[a] (Class 2)	40% - 55%[a]	5% to 85% 82°F Max Dewpoint[c]	Max 55%[e]
Filtration quality	65%, min. 30%[b] (MERV 11, min. MERV 8)[b]			

[a]These conditions are inlet conditions recommended in the ASHRAE Publication *Thermal Guidelines for Data Processing Environments* (ASHRAE, 2004).
[b]Percentage values per ASHRAE *Standard* 52.1 dust-spot efficiency test. MERV values per ASHRAE Standard 52.2. Refer to Table 8.4 of this publication for the correspondence between MERV, ASHRAE 52.1 & ASHRAE 52.2 Filtration Standards.
[c]Telecordia 2002 GR-63-CORE
[d]Telecordia 2001 GR-3028-CORE
[e]Generally accepted telecom practice. Telecom central offices are not generally humidified, but grounding of personnel is common practice to reduce ESD.
[f]Refer to Figure 2.2 for temperature derating with altitude

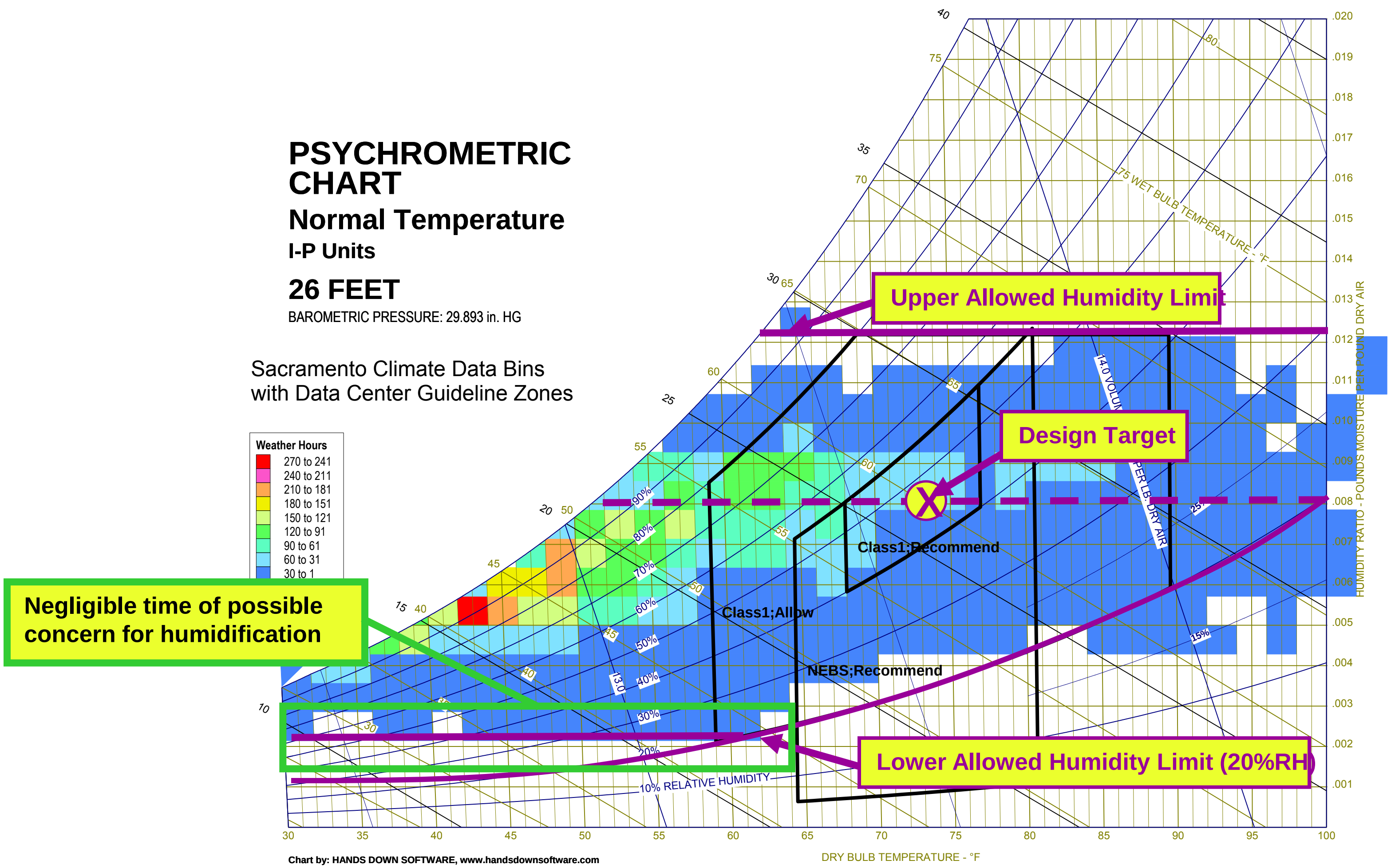
San Francisco



Los Angeles


PSYCHROMETRIC CHART
Normal Temperature
I-P Units
105 FEET
BAROMETRIC PRESSURE: 29.808 in. HG
Los Angeles Climate Data Bins
with Data Center Guideline Zones
Weather Hours
396 to 353
352 to 309
308 to 265
264 to 221
220 to 177
176 to 133
132 to 89
88 to 45
44 to 1
Upper Allowed Humidity Limit
Design Target
Class1;Recommend
Class1;Allow
NEBS;Recommend
Lower Allowed Humidity Limit (20%RH
Only a few hours of possible concern for humidification
75 WET BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
DRY BULB TEMPERATURE - °F
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com

Sacramento


PSYCHROMETRIC CHART
Normal Temperature
I-P Units
26 FEET
BAROMETRIC PRESSURE: 29.893 in. HG
Sacramento Climate Data Bins
with Data Center Guideline Zones
Weather Hours
270 to 241
240 to 211
210 to 181
180 to 151
150 to 121
120 to 91
90 to 61
60 to 31
30 to 1
Negligible time of possible concern for humidification
Upper Allowed Humidity Limit
Design Target
Class1;Recommend
Class1;Allow
NEBS;Recommend
Lower Allowed Humidity Limit (20%RH)
75 WET BULB TEMPERATURE - °F
14.0 VOLUME CU. FT. PER LB. DRY AIR
10% RELATIVE HUMIDITY
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
DRY BULB TEMPERATURE - °F
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com

Lower humidity limit

- Mitigate electrostatic discharge (ESD)
  - Recommended procedures
    - Personnel grounding
    - Cable grounding
  - Recommended equipment
    - Grounding wrist straps on racks
    - Grounded plate for cables
    - Grounded flooring
    - Servers rated for ESD resistance
  - Industry practices
    - Telecom industry has no lower limit
    - The Electrostatic Discharge Association has removed humidity control as a primary ESD control measure in their ESD/ANSI S20.20 standard
  - Humidity controls are a point of failure and are hard to maintain
  - Many data centers operate without humidification
  - This needs more research
- And for some physical media (tape storage, printing and bursting)
  - Old technology not found in most data centers
  - It is best to segregate these items rather than humidify the entire data center

ESD control: floor grounding

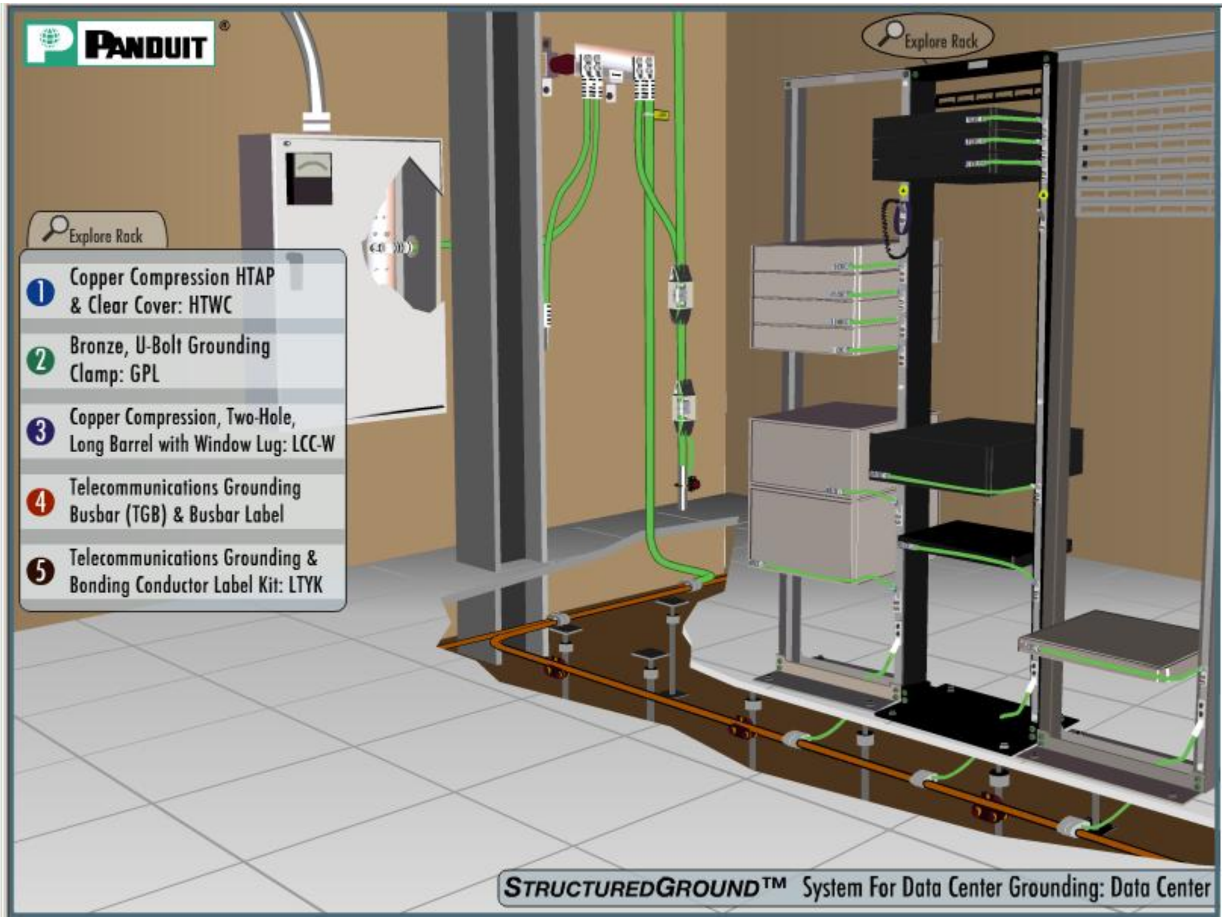


Image from Panduit, reprinted with permission

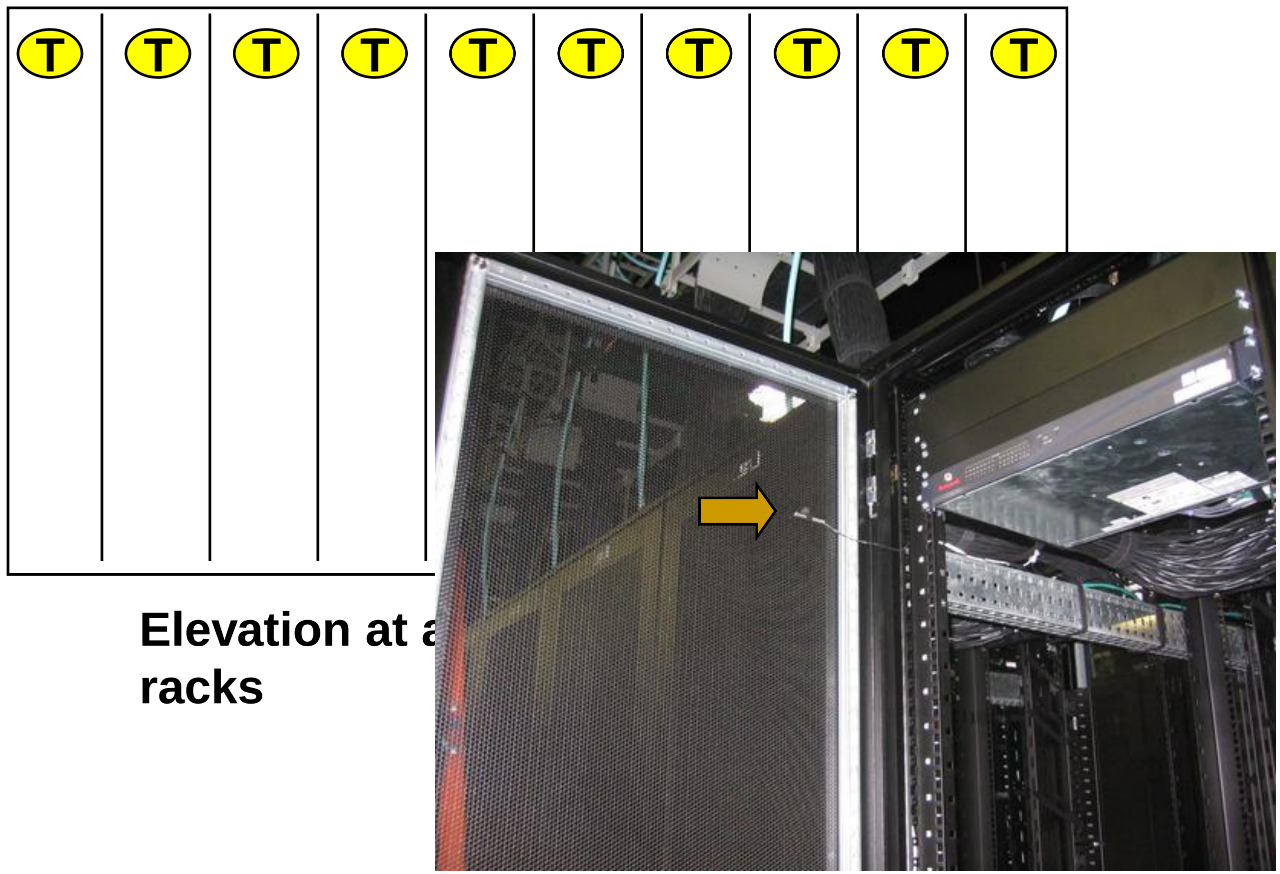
Temperature Control

- Design Conditions
  - Maintain inlet conditions at servers between 68°F and 77°F
    - 59°F to 90°F allowable
    - At 77°F most server two speed fans go into high speed
- Solutions
  - Feedback from racks
    - Hardwired or wireless EMCS sensors
    - Network data exchange with server on-board sensors
  - Reset supply temperatures upward to keep most demanding rack satisfied
  - Can have local temperature zones with distributed CRAC/H units

Rack temperatures with UF supply

1. **Reset SAT to keep rack EATs within design range**

2. **Keep SAT above minimum for design**



Elevation at a
racks

Humidity Control

- Avoid if at all possible
  - High humidity is usually limited by cooling coil dew-point temperature
  - Low humidity limit is not well supported (see previous slides)
- If you decide to humidify, do all of the following:
  - Use high quality dew-point sensors located in the data center floor (Visalia see NBCIP report: http://www.buildingcontrols.org/publications.html)
  - Use adiabatic (not steam) humidifiers
    - Direct Evaporative Media
    - Infrared
    - Ultrasonic
  - Best to provide on MUA unit.
  - Control all humidifiers together if distributed.

Example survey of CRACs

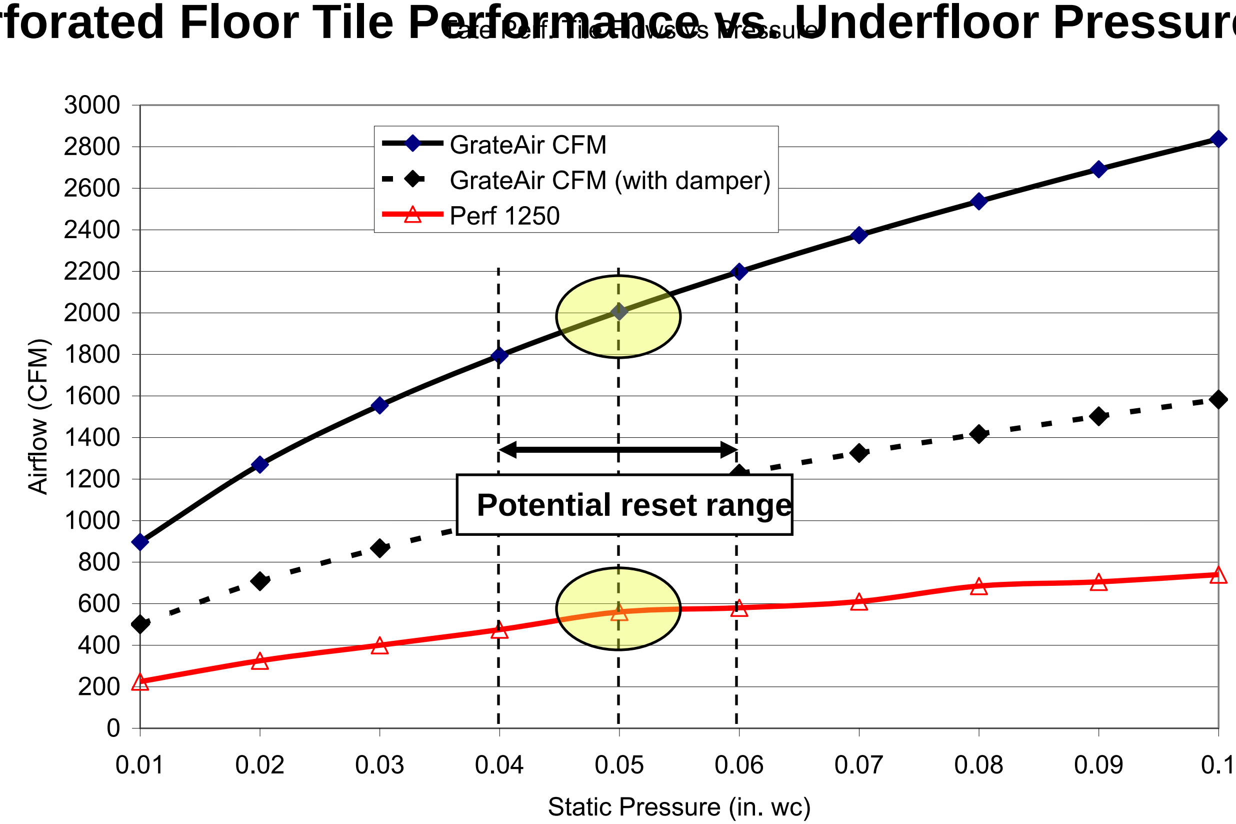
	Visalia Probe			CRAC Unit Panel			
	Temp	RH	Tdp	Temp	RH	Tdp	Mode
AC 005	84.0	27.5	47.0	76	32.0	44.1	Cooling
AC 006	81.8	28.5	46.1	55	51.0	37.2	Cooling & Dehumidification
AC 007	72.8	38.5	46.1	70	47.0	48.9	Cooling
AC 008	80.0	31.5	47.2	74	43.0	50.2	Cooling & Humidification
AC 010	77.5	32.8	46.1	68	45.0	45.9	Cooling
AC 011	78.9	31.4	46.1	70	43.0	46.6	Cooling & Humidification
Min	72.8	27.5	46.1	55.0	32.0	37.2	
Max	84.0	38.5	47.2	76.0	51.0	50.2	
Avg	79.2	31.7	46.4	68.8	43.5	45.5	

Airflow controls under-floor (UF)

- All supply fans controlled to same speed
- Set speed to maintain differential pressure setpoint under floor (can use multiple sensors)
- Reset differential pressure setpoint by highest rack temperature (slow acting loop)

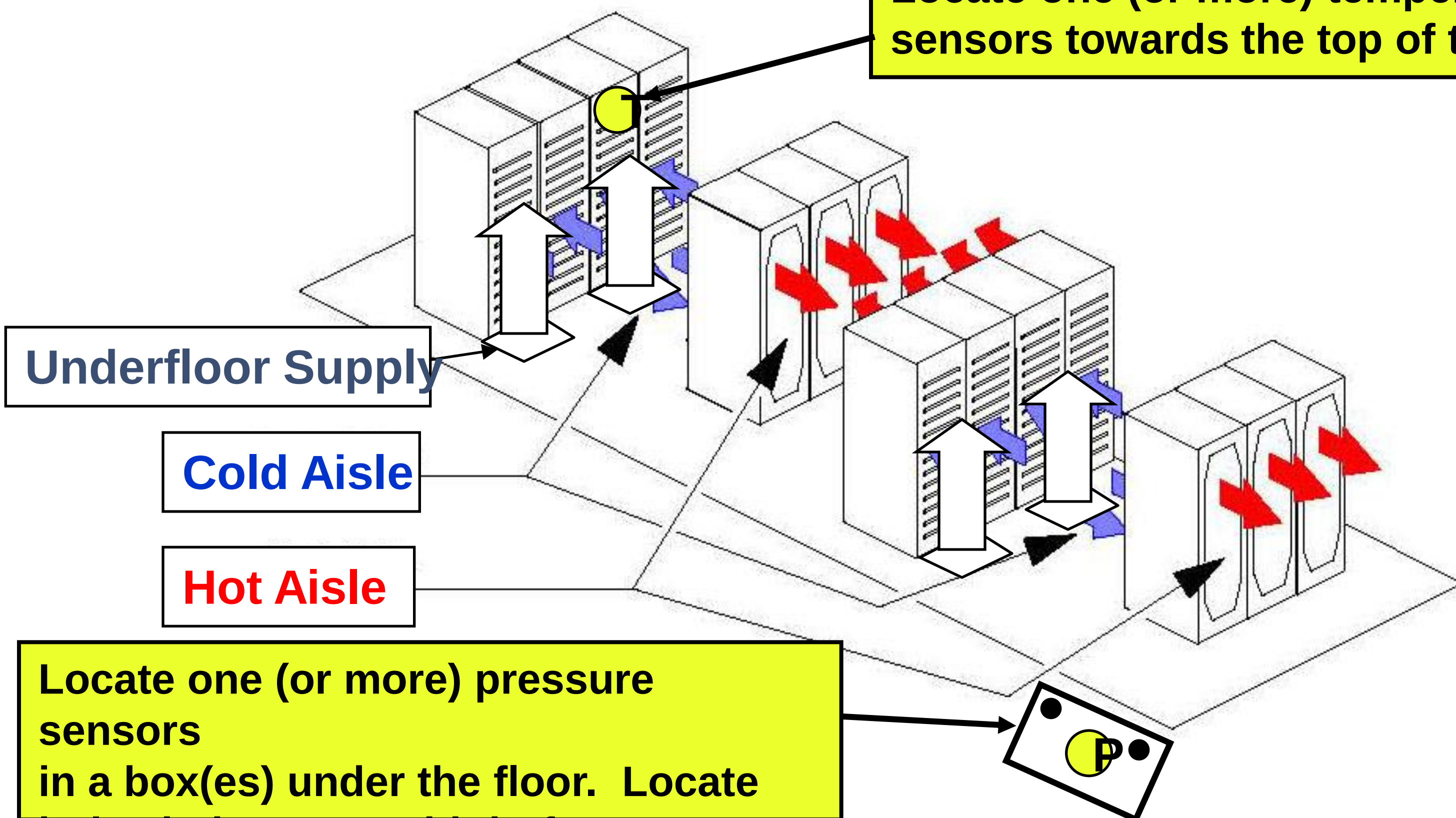
Reset of floor pressure to satisfy racks

Tate Perforated Floor Tile Performance vs. Underfloor Pressure



Control sensors under-floor (UF)

Locate one (or more) temperature sensors towards the top of the racks

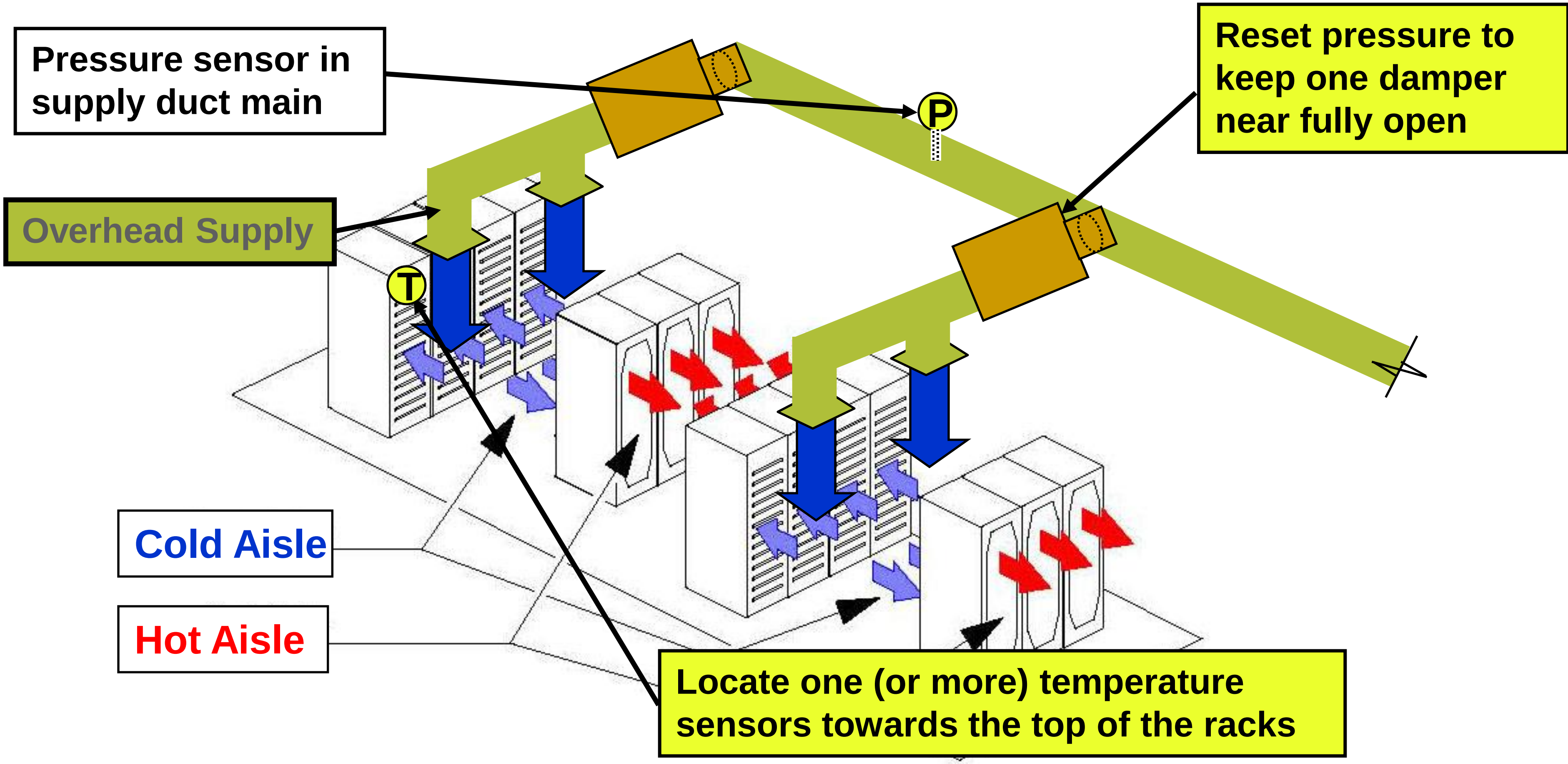


Locate one (or more) pressure sensors
in a box(es) under the floor. Locate holes in box to avoid drafts on sensor tip

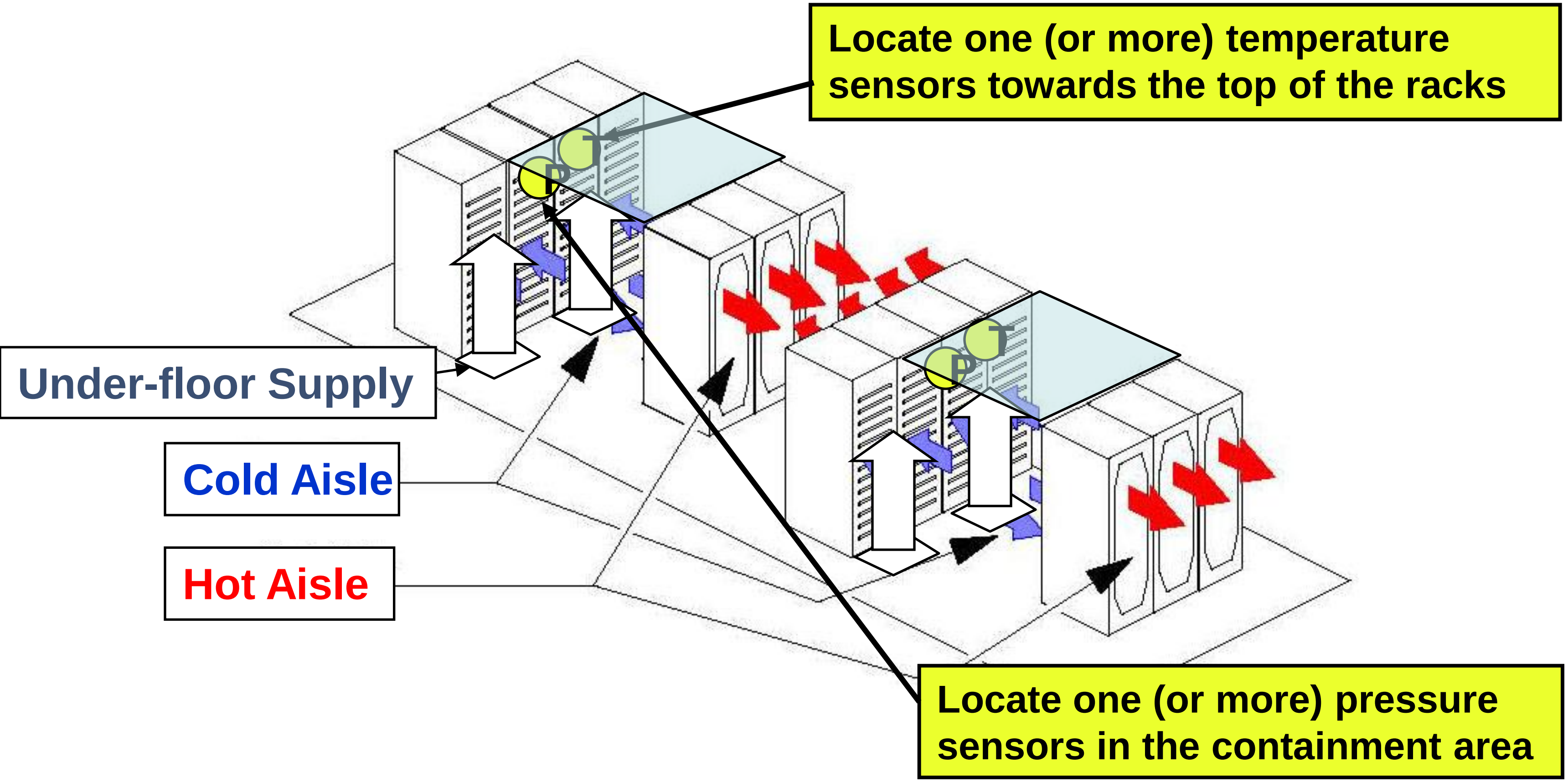
Airflow controls over-head (OH)

- All headered supply fans controlled to same speed
- Set speed to maintain pressure in supply header
- Control dampers to maintain racks at temperature
- Reset pressure setpoint to keep most open damper at or near fully open

Data center layout



Control sensors with cold-aisle containment



Feedback and diagnostics

- Normal Indices
  - SAT (or RAT)
  - CHWS
  - Equipment Status
  - Space Temp
  - Space RH (or return RH)

- Improved Indices
  - Rack Cooling Index (see next slide)
  - Plant kW/ton
  - LBNL’s Data Center Metric Phvac/Pservers
  - Most open valve status (and location)
  - Most open damper status (and location)
  - Air management

$$RTI = \frac{\Delta T_{ACs/AHUs}}{\Delta T_{Servers}}$$

Rack Cooling Index (RCI)

$$RCI_{HIGH} = \left(1 - \frac{\sum_i (T_i - 77)}{n \times (90 - 77)} \right) X100\%$$

$$RCI_{LOW} = \left(1 - \frac{\sum_j (68 - T_j)}{n \times (68 - 59)} \right) X100\%$$

(Numbers reflect ASHRAE Class 1 conditions, generalized equations on next slide)

Herrlin, M. K. 2005. Rack Cooling Effectiveness in Data Centers and Telecom Central Offices: The Rack Cooling Index (RCI). ASHRAE Transactions, Volume 111, Part 2, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

Rack Cooling Index (RCI)

$$RCI_{HI} = \left[1 - \frac{\sum_{x=1}^{n} (T_x - T_{max-rec})}{(T_{max-all} - T_{max-rec})n} \right] 100[\%] \; (for \, T_x > T_{max-rec})$$

$$RCI_{LO} = \left[1 - \frac{\sum_{x=1}^{n} (T_{min-rec} - T_x)}{(T_{min-rec} - T_{min-all})n} \right] 100[\%] \; (for \, T_x < T_{min-rec})$$

T_x	Temperature at equipment intake x
n	Total number of intakes
$T_{max-rec}$	Max recommended intake temperature
$T_{max-all}$	Max allowable intake temperature

T_x	Temperature at equipment intake x
n	Total number of intakes
$T_{min-rec}$	Min recommended intake temperature
$T_{min-all}$	Min allowable intake temperature

Herrlin, M. K. 2005. Rack Cooling Effectiveness in Data Centers and Telecom Central Offices: The Rack Cooling Index (RCI). ASHRAE Transactions, Volume 111, Part 2, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

Return Temperature Index (RTI)

$$RTI = \left[\frac{T_R - T_S}{\Delta T_{Equip}} \right] 100[\%]$$

T_R	Return temperature (airflow weighted)
T_S	Supply temperature (airflow weighted)
ΔT_{Equip}	Average temperature rise across equipment (airflow weighted)

Herrlin, M. K. 2008. Airflow and Cooling Performance of Data Centers: Two Performance Metrics. *ASHRAE Transactions, Volume 114, Part TBD, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.*

IT integration

- Control system server
  - Who provides it
  - Where is it located
- Data exchange on server temperatures or fan speeds (SNTP)
- Gateways
  - CRAC/H unit controls
  - VSDs
  - Electrical Panels

Other issues

- Power down restart sequences
- Control system redundancy (e.g. chillers)
  - Distributed controllers (one per chiller)
  - Redundant controllers (with heartbeat and transfer switches)
  - See Engineered Systems September 2007 Article —Mission Critical Building Automation.”
- Testing coordination (see Cx section)
- Remote access/security

Best Practice Controls

- Use high quality sensors
- Reset temp and pressure by demand at racks
- Avoid humidity controls if possible, if necessary provide it on MUA unit
- With VS fans control all in parallel to same speed
- Used advanced whole system metrics to track system performance
- Commission the controls thoroughly

Control take aways

- Environmental conditions recommended by ASHRAE can save over traditional practices
- Humidity ranges can be broad—or no humidity control in CA
- Airflow should be controlled to meet server required flow
- Variable speed fans should be used
- Commission the controls thoroughly